MAG REGIONAL FREEWAY BOTTLENECK STUDY

TASK 13
FREEWAY CAPACITY ENHANCEMENT WORKING PAPER
Draft

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***Submitted to*:**
THE MARICOPA ASSOCIATION OF GOVERNMENTS

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FREEWAY CAPACITY ENHANCEMENT

PURPOSE

This report deals with enhancing capacity in existing freeway corridors. The first section discusses congestion in the MAG region and compares the MAG region with other regions in the United States. The next section of the report discusses a number of capacity enhancing solutions to congestion problems in major urban areas throughout the world. These concepts will then be considered in future working papers that evaluate the potential to increase capacity in MAG regional freeway corridors.

CONGESTION IN THE MAG REGION

Simply put, the congestion problem in the MAG region is that the growth of demand for our roadway system is out-pacing the construction of new roadways. From 1989 to 1998, when aggressive roadway building resulted in a 29% increase in capacity-miles of roadway, the population increased 39% resulting in a 42% increase in vehicle-miles-of-travel on the roadway system. The percentage of congested intersections during the afternoon peak period increased from 23 to 39 percent and the congested freeway miles rose from 21 to 31 percent.

With the population expected to double (to 6 million) in the MAG region over the next twenty to thirty years, and the current Regional Transportation Plan including only a 29% increase in roadway capacity, congestion will certainly be a growing problem in the region.

The increase in traffic congestion is not unique to the MAG region. In the "2002 Urban Mobility Study" prepared by the Texas Transportation Institute (TTI), urban congestion trends were evaluated for 75 urban areas in the United States over the period from 1982 to 2000. The population of the urban areas in the study ranged from 17,090,000 in New York City to 110,000 in Boulder, Colorado.
General conclusions drawn by TTI are:

> Congestion is growing in areas of every size with all of the size categories showing more severe congestion that lasts a longer period of time and affects more of the transportation network in 2000 than in 1982.
> The average annual delay per peak road traveler climbed from 16 hours in 1982 to 62 hours in 2000.
> Between 1982 and 2000, passenger-miles of travel increased over 85 percent on freeways and major streets and about 25 percent on transit systems.

The total congestion "bill" for the 75 urban areas in 2000 was $67.5 billion, which was the value of 3.6 billion hours of delay and 5.7 billion gallons of excess fuel consumed.
Since the primary purpose of this analysis is to compare future Phoenix to other large cities, it was decided to focus on cities larger than Phoenix in 2000. It was also decided to exclude the New York City urban area from the analyses because its central core density and transportation system differ so drastically from all other urban areas in the nation. The

selection of urban areas to compare included all areas with a 2000 population of 2 million or more. A total of 17 urban areas, as listed in Table 2.1, were used in the comparisons. One conclusion that can be drawn from the TTI data is that the MAG region has few freeways relative to its population. Table 1 contains: the population, lane miles of freeway, and freeway VMT for comparable urban areas. One should observe that the population of the MAG region would be larger in 20 years than the current population of all of the urban areas in Table 1, except Chicago and Los Angles.

Table 1

Sorted by Population	**2000 Population (1000s)**	**Urban Area Freeways**	
		Lanes Miles	**VMT***
Los Angeles	12,680	5,400	126,495
Chicago-NE IL	8,090	2,665	36,225
Philadelphia	4,590	1,740	25,445
San Francisco	4,030	2,335	47,980
Detroit	4,025	1,815	31,125
Dallas-Forth Worth	3,800	3,150	48,700
Washington DC	3,560	1,885	34,535
Houston	3,375	2,475	37,900
Boston	3,025	1,305	22,500
Atlanta	2,975	2,315	42,940
San Diego	2,710	1,795	33,745
Phoenix	**2,600**	**1,030**	**19,425**
Minn/St. Paul	2,475	1,580	27,095
Miami-Hialeah	2,270	750	13,585
Baltimore	2,170	1,475	22,660
St. Louis	2,040	1,130	25,740
Seattle	2,000	1,285	22,455

Table 2 contains a comparison of the lane miles of freeway per capita in the same urban areas as table one. It is clear Phoenix has relatively few lane miles of freeways compared to other large areas. This situation could decrease to .25 freeway lane miles per 1000 capita by 2030 if only the currently planned roads are constructed.

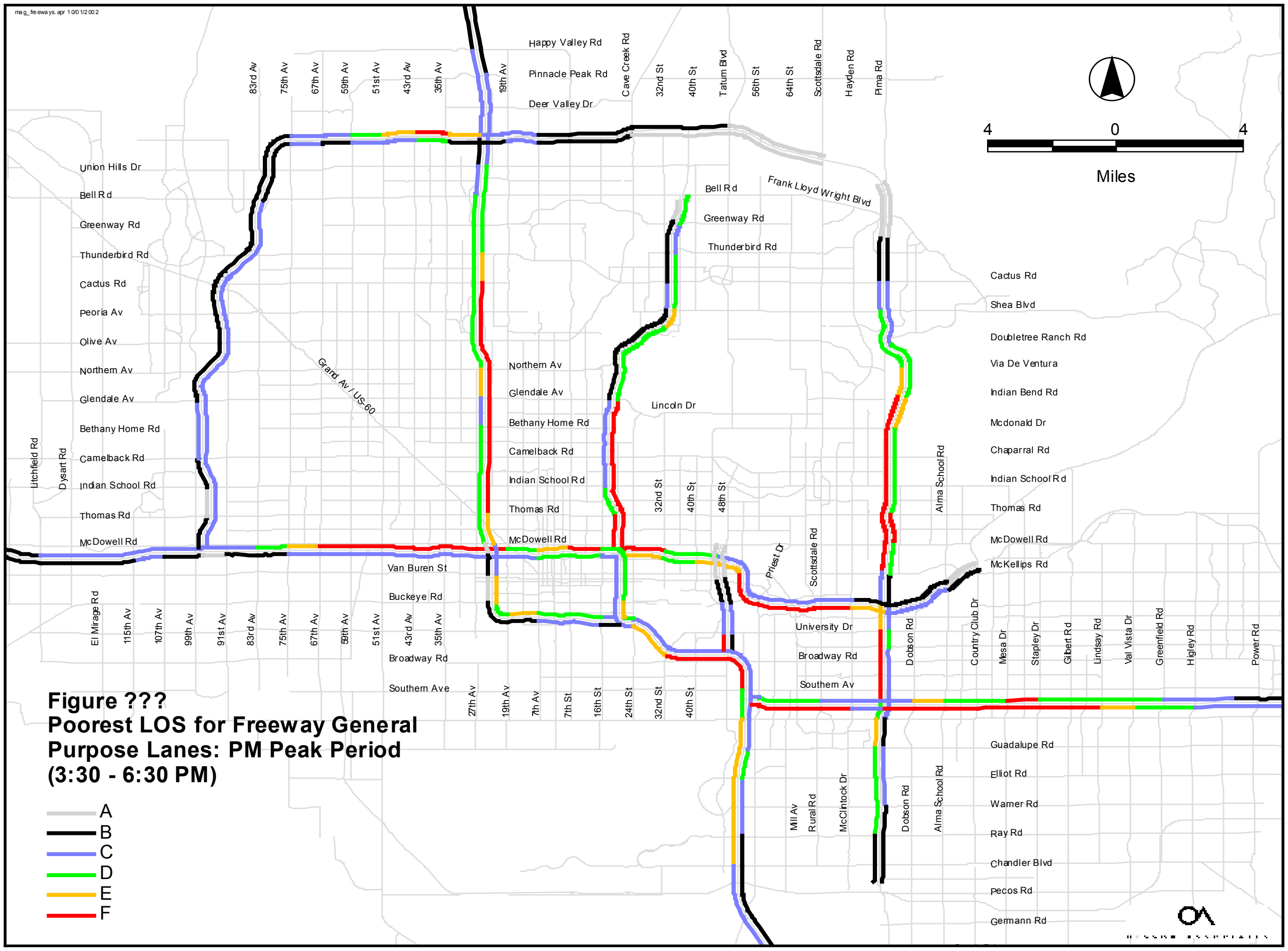
Table 2

Sorted by Miles/Capita	**Freeway Lane Miles per 1,000 Capita**
Dallas-Fort Worth	0.829
Atlanta	0.778
Houston	0.733
Baltimore	0.680
San Diego	0.662
Seattle	0.643
Minn/St. Paul	0.638
San Francisco	0.579
St. Louis	0.554
Washington DC	0.529
Detroit	0.451
Boston	0.431
Los Angeles	0.426
Phoenix	**0.396**
Philadelphia	0.379
Miami-Hialeah	0.330
Chicago-NE IL	0.329

On the other hand, among these 17 urban areas, Phoenix is second only to Los Angeles and San Francisco and followed closely by San Diego in VMT per freeway lane mile. This statistic indicates that Phoenix is getting a very high utilization of its freeways. The high rate may be due to more "round-the-clock" driving and/or higher flow rates during the peak hours. The high flow rates may be due in part to the successful deployment of the freeway management system, which helps to even out peak flows and to reduce the impact of incidents.

In order to keep the regions current level of mobility over the next 30 years the region will need to construct 2 to 4 times more lane miles of freeways then currently planned. This will be difficult since much of the demand will be in currently congested areas in the central part of the region (see Figure 1), which are heavily developed. Innovative thinking will be required in order to meet the challenges posed by the regions rapid growth.

Figure 1: Freeway LOS, PM Peak Period, 2001



MAG currently has a number of studies underway to deal with congestion issues in the region:

- The HOV/HOT Lane Study assesses High Occupancy Vehicle and High Occupancy Toll lanes;
- A Regional Transportation Plan in conjunction with three area transportation plans are determining the need for new roadway facilities in the region;
- The High Capacity Transit Plan and the Regional Transit System Study are looking at both long- and short-term transit needs;
- The East-West Mobility Study is looking at both roadway and transit solutions to congestion in a specific corridor;
- The Freeway Bottleneck Study is looking at relatively low cost solutions to bottleneck locations on the existing freeway system.

EXAMPLES OF CAPACITY ENHANCEMENT

The following information on innovative approaches for expansion of urban highway capacity in present or planned use throughout the world today was provided by Peter Samuel. Peter Samuel is editor of TOLL ROADS NEWSLETTER described as the "monthly on turnpikes, tolling and road price issues," established in March of 1996. He is a North American correspondent for WORLD HIGHWAYS and INTELLIGENT TRANSPORTATION SYSTEMS INTERNATIONAL magazines of London. He has an honors degree in economics from the University of Melbourne, Australia and has been a reporter and commentator on a range of public policy issues for a variety of newspapers and magazines in Australia, and since 1980 in the U.S. and has written for think tanks including the Cato Institute. He works out of Frederick, Maryland on the edge of the Washington DC area.

It is often said, "We don't have space for new roads." It is true that a lot of the easier methods of widening roads in American cities have indeed already been applied. Highways designed with wide grass central medians have generally been paved inwards. However, there are still opportunities in many U.S. urban highway corridors to widen outward. A recent review of major freeways in the Los Angeles area looked for opportunities for widening to add an extra four lanes to existing eight- and ten-lane freeways. Surprising to many it found that about 118 miles out of 136 miles have space within the existing right of way or require only small land purchases for the necessary widening. A rather similar situation occurs on the busy I-635 LBJ Freeway in the Dallas-Fort Worth area and on the I-10 Katy Freeway in Houston, where substantial widening from 8 or 10 lanes to 14 and 16 lanes are planned. On the Washington Beltway in Virginia a recent study similarly found there is space for a planned widening to 12 lanes from the present 8-lanes, except at interchanges where extra slivers of land are required for modern direct connector ramps.

In many places sloped edges can be replaced by retaining walls and ramps can be rebuilt, though in all Los Angeles, Dallas some sections will require a choice between acquiring strips of adjacent land to maintain a single grade or going to a double-deck structure of some kind.

If going outwards is politically impossible or too expensive, the alternatives are going up or going down to make extra road space. If neighbors are willing to sell adjacent land then simple widening of major highways is an option that needs to be weighed against the extra cost of double decking, or undergrounding. Entirely above-ground freeways may go the way of early elevated transit lines (the " Els" of New York City) and be torn down to be replaced by sub-surface or fully underground roads – as is happening in Boston with the underground Central Artery replacing the elevated John Fitzgerald Expressway (I-90). In Brooklyn, NY the Gowanus Expressway, built atop the structure of an abandoned Third Avenue BMT El rail line, is the source of studies and controversy over whether it should be renovated as an 'El'-highway or torn down and replaced with a tunnel. Similar argument is likely over renovations of I-95 along the Delaware River through downtown Philadelphia. In South Pasadena California completion of an important missing link between the present northern end of I-710 and I-210 will revolve around tunnels.

Many urban areas have faced the same increasing congestion issues that the MAG region is facing today. Following are descriptions of some capacity enhancement projects, providing either elevated roadways or tunnels, that have been implemented or are being planned in other metropolitan areas around the world. Additional tables are listed in Table 3.

Table 3. Major Capacity Enhancement Projects

Location	Route	Description
Chicago, Illinois	Chicago Skyway	12.6 miles of elevated roadway
New York, New York	FDR Drive	Double-Decking
Manilla, Philippines		Double-Decking
Bangkok, Thailand		Double-Decking
Osaka, Japan		Double-Decking
Tokyo, Japan		Double-Decking
Tokyo, Japan	Central Circular Highway	9 miles of underground highway
Graz, Austria	Plabutsch Tunnel	6.1 mile tunnel
London, England	Limehouse Link tunnel	1.2 mile tunnel
Zurich, Switzerland	Western Bypass	5.2 miles in tunnel
Lyon, France	Northern Ring Road	4 miles in tunnel
Sydney, Australia	Eastern Distributor Roadway	1.1 mile “piggy-back” tunnel - (3-lanes atop 3-lanes)
Singapore	Kallang & Paya Lebar (KPE) Expressway	5.6 miles in tunnel

Boston, Massachusetts: The Big Dig

The Central Artery/Tunnel (CA/T) Project, also known as the Big Dig, is the largest, most complex highway project in American history. Its scope and complexity have been compared to other engineering projects like the Panama Canal and the Chunnel. However, the CA/T Project is unprecedented since all construction is taking place in the heart of one of America's oldest and most historic cities, which must remain open and accessible for businesses, residents and tourists throughout more than a decade of construction. The project has two major components:

> The six-lane elevated highway (I-93) will be replaced with an eight-to-ten-lane underground expressway directly beneath the existing road, culminating at its northern limit in a 14-lane, two-bridge crossing of the Charles River. When the underground highway is finished, the crumbling elevated road will be demolished and replaced by open space and modest development.
>
> I-90 (the Massachusetts Turnpike) will be extended from its current terminus south of downtown Boston through a tunnel beneath South Boston and Boston Harbor to Logan Airport.

Altogether, the CA/T project is building 161 lanes miles of highway in a 7.8 mile corridor, about half in tunnels, including four major highway interchanges. The old road has 27 on- and off-ramps; the new one will have just 14. With an improved surface street system, local traffic will get off the main highway and distribute itself on the surface, with through traffic moving more easily through the city.

Work on the Big Dig is projected to be completed by 2005. When it's all done, workers will have excavated 14 million cubic yards of earth, enough to fill a professional sports stadium fourteen times. The total cost will likely approach $15 billion, up from the 2.5 billion (excluding mitigation) forecast in 1983.

Los Angeles, California: I-10 (Harbor Freeway)

Just south of Los Angeles a 2.6-miles long section of the I-110 (Harbor Freeway) has been double-decked to accommodate four-lanes of HOV. Called the Harbor Transitway it also includes 7.7-miles of surface roadway where widening was possible. The elevated structure is built on massive earthquake resistant Y-shaped piers set centrally in the lower roadway and is about 50-feet above it. It is this high in order to go over the top of frequent overbridges of cross streets, so in effect it is at a third level. (Figure 2)

Oakland, California: I-880 (Cypress Freeway)

In Oakland the elevated double-deck Cypress Freeway (I-880) collapsed during the devastating Loma Prieta Earthquake of October 1989. There were several years of discussion about whether and how to replace it. Like many such large elevated structures it was locally detested as a "Chinese Wall" that visually and psychologically divided the heart of Oakland. Undergrounding was not an option since it was linked to elevated freeways on one end and to the also elevated approaches to the San Francisco Oakland Bay Bridge on the other. The final compromise was to build a new elevated structure. But this is on a different alignment curving around on the western fringe of the city along a railroad line next to the port, rather than in the middle of the city. In addition the new structure is single deck and much lighter, and quite elegant in appearance. (Figure 5)

San Antonio, Texas: I-35 and I-10

In San Antonio, Texas I-35 also has a double-deck elevated section 1.3 miles long with local connections catered to by four freeway lanes near or at ground level and through traffic above on another six freeway lanes. The double-decking consists of lanes that cantilever over the lower level from both sides (Figure 6). The second deck was built in the late 1980s.

The other major freeway that goes through San Antonio (I-10) has a similar double-decked segment of about 1.5 miles. It is also 2x3-lanes on top of the old 2x2-lane freeway below and was built in the 1980s as well.

Tampa, Florida: (Lee Selmon Cross-town Expressway)

A quite different long elevated has just started construction near Tampa Florida. Various alternative widenings of the existing two-by-two lane Lee Selmon Cross-town Expressway have been examined. All detracted from the parkway-like ambience of the toll road that meanders along the banks of a tidal river and in a grassy green and mangrove setting. Some widenings raised wetland issues and others required extensive property acquisition. The road forms the main link to Tampa's reviving harbor side downtown area from the east and badly needs enhanced capacity for "tidal" traffic flows – both of commuters on a daily basis and for other major traffic generating events like large cruise ships, sporting events and conventions. Evacuation for a hurricane or a major terrorist incident might also benefit from the extra capacity.

The Tampa Hillsborough County Expressway Authority has just started construction of an elegant solution – a reversible elevated road or bridgeway built on a single row of wide-spaced sculpted piers set in the grassy median. The bridgeway will run right over the top of the existing toll plaza and have no cash toll, most of its users being tolled via their windshield-mounted transponders at full highway speed. (Others could call to pay giving their license plate number.) The first segment is 2-lanes reversible 6/10 mile and will flow into the main 3-lanes reversible bridgeway of 5.4 miles for a total elevated not much short of the Chicago Skyway length. Advances in technology – especially match-cast prefabricated concrete box girder construction – and attention to esthetics allow far more appealing elevated roads. (See www.tamp-xway.com) (Figure 7)

Dallas-Fort Worth, Texas: LBJ Corridor

The I.H. 635/LBJ Freeway (LBJ) corridor is located in the Dallas-Fort Worth metropolitan area. The study corridor is approximately 21 miles (33.8 km) in length along the northern and eastern sections of the LBJ Freeway extending from west of I.H. 35E to U.S. 80. The corridor is bounded by Belt Line Road and Loop 12. Municipalities located along I.H. 635 include the cities of Dallas, Farmers Branch, Garland, and Mesquite.

LBJ generally consists of eight general purpose lanes plus 4/6 HOV/HOT lanes except at interchanges. One-way service roads are generally two and three lanes wide and are not continuous. Right-of-way (ROW) width varies from 330 feet to 450 feet depending on: the existence of service roads, interchange design, and drainage requirements. The total construciton cost is about 1.7 billion.

Figure 2: Map At Completion, The Big Dig, Boston, USA

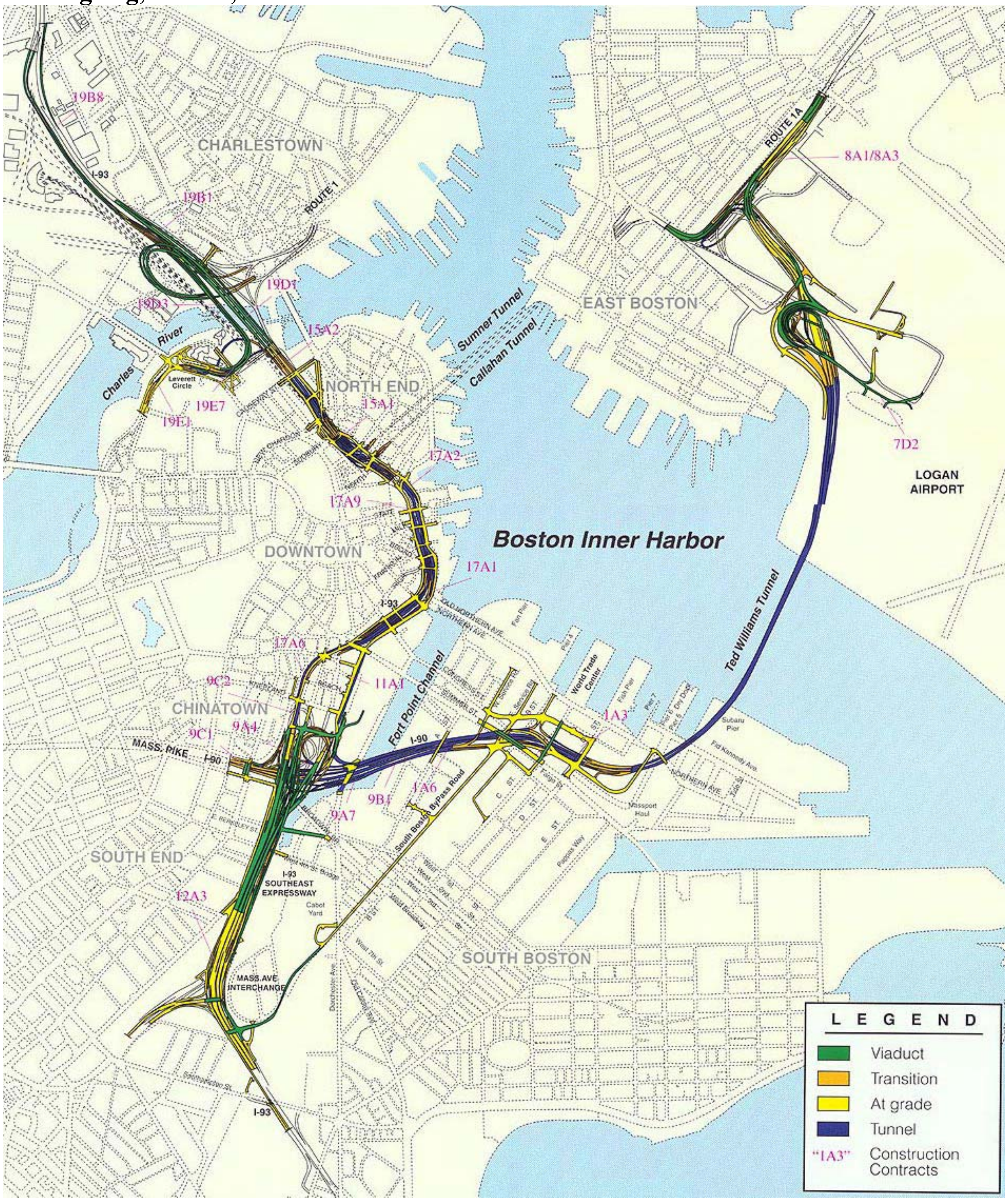
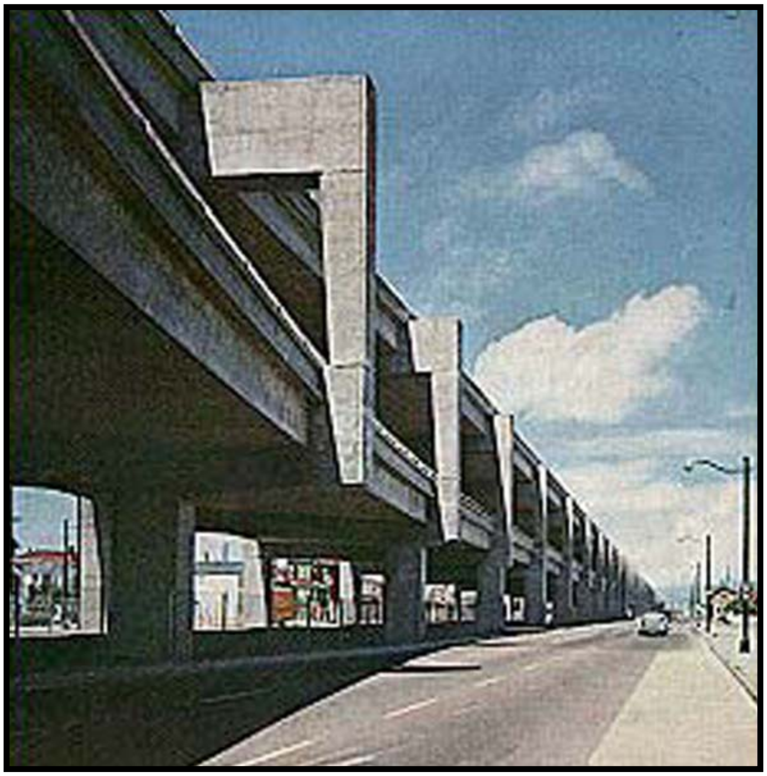


**Figure 3: Tunnel Section,
LBJ Project, Texas, USA**

Figure 4: Harbor Transitway - Los Angeles

Figure 5: Cypress Freeway-Oakland

Old Cypress Freeway



New Cypress Freeway

Figure 6: I-35 – San Antonio

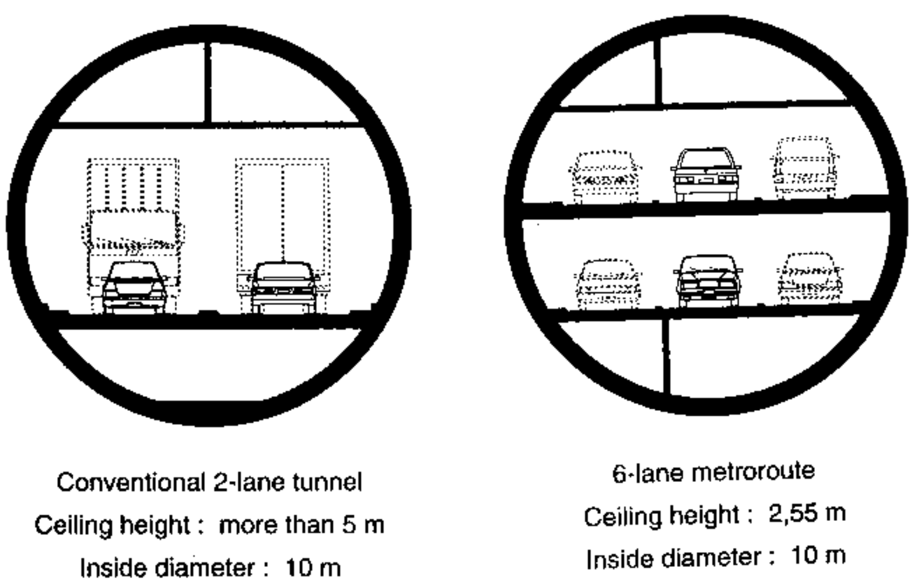
Figure 7: Tampa Expressway

Versailles, France

Near Versailles west of Paris, there has long been a missing link in the outer A86 ring motorway because of the sensitive nature of an area of historic estates, villages, public woods and grand palaces. For 30 years efforts to design a conventional highway link through the area failed. Traffic clogged quaint country lanes and villages because of the lack of a proper through road.

The investor owned toll company Cofiroute proposed a pair of toll tunnelways that constitute a project called in French l'A86 a l'Ouest, or A86-West. The first, tunnelway from Rueil-Malmaison to Pont Colbert, now under construction, involves a bored tunnel 6.3 miles long with two decks inside. Midway it will rise nearly to ground level to send off ramp tubes that will be an underground interchange with the A13 motorway. This tunnelway will permit only low vehicles of up to 6'-7" height with 8'-4" headroom in 10' wide lanes. But this allows six-lanes of traffic along with separate fresh and exhaust air ducts to be accommodated in the interior of a 34' diameter tube built by a tunnel-boring machine. Over 90 percent of the potential traffic will fit in this tunnel. Its tight dimensions mesh with a planned 43 mph speed limit. Tolls will be varied to prevent excessive traffic and assure free flow at this moderate speed. (Figure 8)

Figure 8: Toll Tunnel – Versailles, France



Source : Société COFIROUTE.

The same tunnel-boring machine will be used to build a second westerly tunnel, Rueil Malmaison to Bailly, 4.7 miles long for mixed traffic with headroom for full height tractor-trailers. The project involves no public funds.

Stockholm, Sweden Underground Ring Road

In central Stockholm, Sweden a 12-mile underground ring road with many subsurface interchanges was designed in the mid-1990s to go around the historic center of the capital city. (Figure 9) It was designed to allow through traffic to be banned from local streets. And there were to be underground parking garages connected to the underground ring. Environmentalist opposition and cost increases have delayed it but a southern section (Sodra Lanken) is under construction with four underground interchanges (see www.taurnet.se/sedralnk.htm) and a northern portion is being pursued. The Swedish road authorities sponsored a great deal of research and experimentation in ways of making road tunnels more comfortable for motorists with new designs for lighting and ceiling and wall shapes.

Figure 9: Underground Ring Road – Stockholm, Sweden

Oslo, Norway: Tunnelways

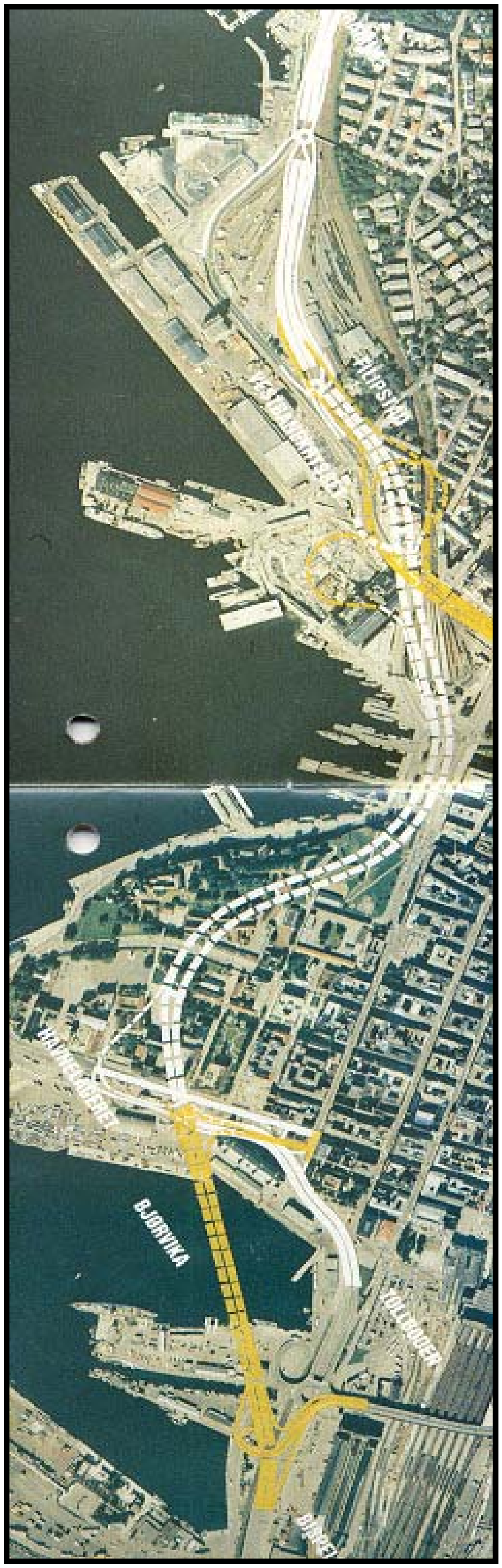
Oslo is the major population center of Norway with about 900,000 people. A strong environmental ethic, activist politics, many historic buildings and a rugged terrain meant an American-style freeway system was out of the question. Plans for a continuous urban network ran into neighborhood opposition and lack of money, and only small segments of motorway got built, the main roads mostly lacking grade separation. According to the Norway Public Roads Administration the initial belief was that "developing a public transport system was the answer to the growing road traffic." As a result the metro was greatly expanded, but "the traffic (on the roads) continued to grow." Oslo was "about to be strangled." (quotes from "Toll Road System in Oslo" Public Roads Administration, Norway, no date)

In 1985 the city council and the national parliament both approved a plan to introduce a comprehensive toll system to build an urban motorway/arterial network, a large portion of it in tunnels. The improvements involved some 50 projects costing about $4 billion. In order to prevent motorists from bypassing the tolled facilities, and in order to raise a major stream of revenue, the plan called for a cordon of toll points on all the major entryways into the city from the suburbs. This was a radical departure from the traditional approach of tolling only the facilities being built and improved, but it was accepted by motorists, although only grudgingly. 18 toll points were established (and another added later). The Oslo toll ring was one of the first major toll systems to make heavy use of toll accounts and wireless transponders mounted on the windshield, though all toll points had automatic coin machines and a few had traditional toll collectors.

The first major project was a two parallel 3-lane motorway tunnels 1.1 miles long under the waterfront in the central business district. It was initially called simply the Oslo Tunnel but is now officially the Festningstunnelen or Castle Tunnels. It is located under about 450 buildings, many of historic importance, but was built without damage. It was built by drill and blast and secured with rock bolts and shotcrete. (Figure 10) It carries some 70,000 vehicles per day and is part of the E-18 national motorway. Four more tunnelways have been completed and another is under construction. Five more tunnelways are planned.

Tolls are collected in-bound – a total of about $240,000 per day or $120 million in revenue with operating costs of $13 million, so over $100 million a year is generated for the new road projects. Approximately 320,000 motorists carry windshield-mounted transponders that do 85 percent of the tolls, most of the remainder being coin machine transactions. The tolls are operated by Fjellinjen AS, a private company owned equally by the city of Oslo and Akershus County, which covers the outer area of the greater Oslo region. Present legislation provides for tolls to be discontinued in 2007, but they may be continued if further road works are wanted. A minority portion – about 20 percent – of net revenue supports public transport.

Figure 10: Castle Tunnels – Oslo, Norway



Melbourne, Australia

Melbourne is Australia's second largest city (population 3.4 million), but largest port and manufacturing center; Melbourne faced a major congestion problem in the early immediate southeast of the central business area. There is a favorite riverfront promenade, long-established city Botanical Gardens, and gentrifying inner suburbs, yet a pressing need for a higher quality highway link. To the west and northwest of the City were freeways that had been truncated and fed into surface signalized arterial streets because of difficulties finding acceptable surface right of way. (see www.transurban.com.au and www.citylink.vic.gov.au)

An investor group (Transurban) consisting of a large local construction company (Transfield), and Japanese tunnelers (Obayashi) with support of French and Swedish systems companies got state approval for a self-financing toll project named CityLink 13.7 miles of six- and eight-lane roadway to the immediate west and south of the central city area linking three previously unconnected freeways and providing new access to the central business district with a combination of elevated and tunnel construction. (Figure 11) Overall cost was $1.2 billion financed by tolls on a 34-year toll concession.

To the northwest, a pair of three-lane elevated roadways has been built along a floodway and creek. An innovative solution was found to highway noise beside a high-rise housing complex. The whole elevated roadway is wrapped for about a thousand feet in an oval section framework, which supports strategically located noise absorbent panels. The 'sound tube' (Figure 12) has received architectural and engineering recognition. In other places there has been extensive use of earth berms, landscape walling, and translucent panels to dull traffic noise.

Figure 11: CityLink – Melbourne, Australia

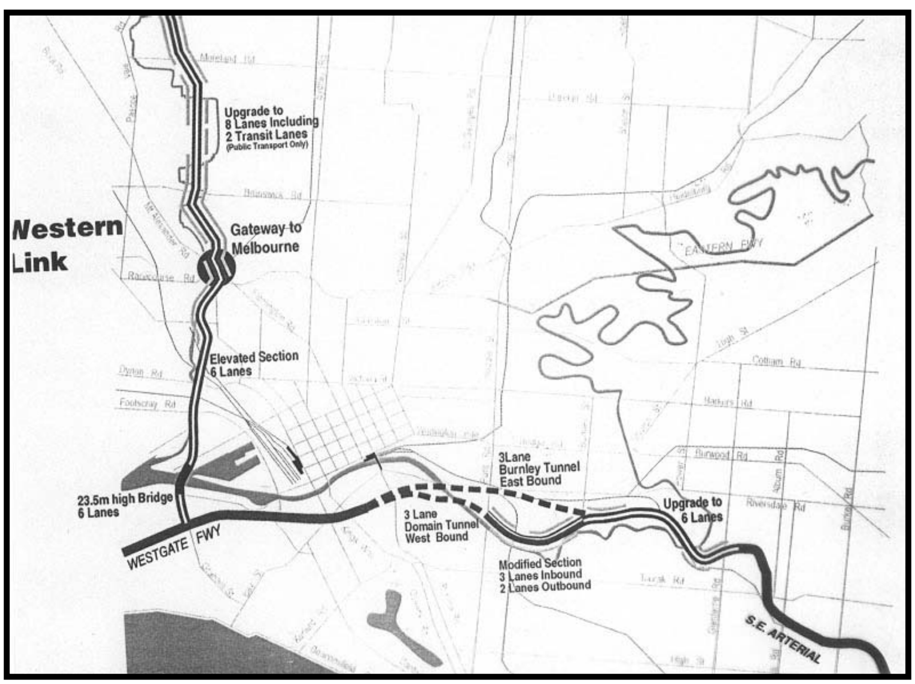
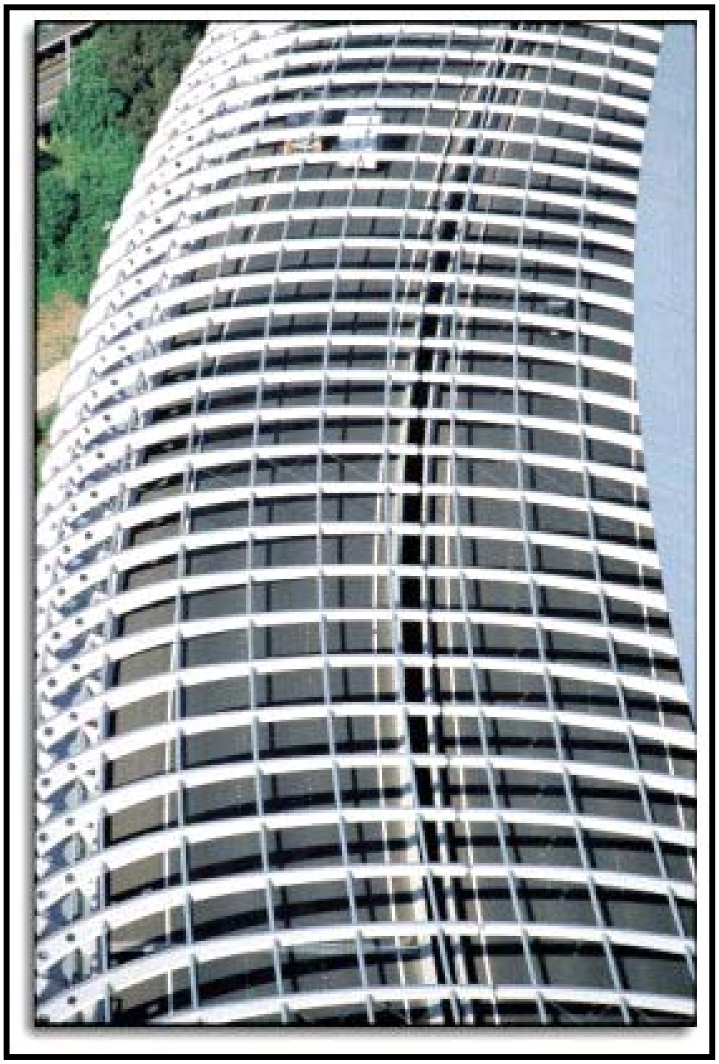


Figure 12: Sound Tube – Melbourne, Australia



Two tunnelways have been built in the most sensitive southeast area, each of three-lanes. The shorter Domain tunnel, one-mile long, to the south is of driven and cut-and-cover construction. It goes under the gardens, the river and riverfront and connects with an existing riverfront road that becomes a westbound roadway. A longer tunnelway to the north the Burnley Tunnel all-driven goes 2.1 miles under not only the gardens and river area but under an inner suburb of renovated 19th century houses. It carries three eastbound lanes.

Time from the southeast to the airport in the northwest is now 39 minutes on CityLink compared to 87 minutes on free surface arterials. For that 48-minute time saving, together with the more relaxing driving experience on a free flow road, nearly 200,000 motorists a day are paying tolls and the project is profitable for the investors. No tax money was needed.

VEHICLE SEGREGATION

Truck Lanes and Truck Roads

In America as elsewhere, large trucks are a hot-button political issue, with truck lobbies constantly pressing for more generous size and weight limits, and motorists' organizations and local activists fighting to stop further truck enlargement. There has been an unproductive fight for years in the U.S. between the motorists' organizations and road safety groups and the truckers, the truckers saying the economy needs to allow larger, heavier trucks and the motorists saying large, heavy trucks are dangerous. They are both right. And here lies the possibility of a compromise that will serve the interests of both – the notion of special truckways, completely separate from mixed traffic roads or consisting of special lanes segregated from the rest by crash-proof concrete barriers.

Segregation Car/Truck Starting

The beginnings of a new kind of truck/light vehicle separation are evident in bans on trucks in the inner lanes of multilane (five or more) expressways or freeways. In Los Angeles there has been a major program in the past six years to squeeze extra lanes out of the existing pavement, by re-striping the old standard 12' freeway lanes to 11'. Studies have shown that both speeds and safety are unaffected by the narrowing of lanes, and in a standard eight-lane LA freeway this change alone contributes eight feet of extra pavement (the rest of what is needed for an extra pair of lanes usually being available in the median or on shoulders). In this "LA squeeze," prohibitions are usually imposed on trucks in the inside lanes. From the other direction, there is pressure to make lanes wider for trucks. The federal width limit on trucks was increased recently from eight to eight and one-half feet and with most truck engines now turbo-charged, trucks are also traveling faster. A number of proposals for new highways (notably the NAFTA Highway Indianapolis-Houston-Laredo Corridor proposal) provide for truck lanes of 13'. Canadian experience with extra-wide timber-jinkers in their mountain provinces has shown wider trailers are safer as well as more productive than those which are made to fit in standard 12' mixed-traffic lanes.

On major truck routes we need to build separate truck roads – call them truckways –where we can cater to the special needs of trucks and provide the most economical mix of roadway dimensions and load carrying capacity for cargo movement. Then we can get the larger trucks out of lanes in which cars travel. This is the only way to make the major highways safe for small vehicles such as cars. About 5,200 Americans die each year in truck-related accidents, most of them car-drivers.

The Pennsylvania Turnpike, which runs 25,000 heavy trucks a day (out of a total of 75,000 vehicles daily), has examined what it called a "dual/dual" concept, a 2/2/2/2 lane profile in which two lanes in each direction would be for heavy trucks and two for light vehicles, but so long as there are free parallel interstates for trucks (I-80 in the north of the state, and I-68 just south in Maryland) it seems unlikely to be a financially viable idea.

DESIGNS FOR RIGHT-SIZED ROADS

Two west coast engineers see truck/car separation as a possible solution to the dilemma of building increased capacity in constrained expressway rights-of-way. Gary Alstot, a transport consultant of Laguna Beach, California, like many other southern Californians, has watched in awe as federal money has been used to build about three miles of double-deck down the middle of I-110 south of downtown Los Angeles as part of its High Occupancy Vehicles (HOV) program. Built as bridgework, on giant T-posts, the double-deck section of four lanes is generally over 50 feet high, because it has to go over the top of interchanges and overcrossings along the way, putting it up three levels.

Alstot, in a paper for the American Society of Civil Engineers, argued that on wide west coast urban expressways, with over 80 percent of the traffic in light vehicles, it is wasteful to build the whole cross-section to heavy truck standards. He pointed out that I-110 could have been double-decked under its overpasses, instead of over them, if the space in the double-deck section was restricted to cars. Alstot thinks 10' lane width would be adequate for passenger cars, with seven-foot overhead clearance, as in parking structures. The average height of 1992 cars was 46" and two-thirds are less than six feet he points out, compared to modern U.S. truck requirements of 14' high and 8.5' wide.

U.S. engineers are following with interest the Cofiroute tunnels for the missing link of the A86 Paris ring road in which similar tubes are planned west of Versailles, one for mixed traffic of two lanes, and the other a cars-only tunnel with two decks of three lanes each. The cars-only tunnel, according to cross-sections provided by the French, will provide for ceilings at 8'-4" and lanes of just under 10' wide, just a little higher but narrower than Alstot's notional cross-section.

Independently, Joel K. Marcuson, formerly of the Seattle office of Sverdrup Civil Inc. and mow with HNTB in Minneapolis, came up with similar ideas while doing research for the Automated Highway System project. Heavy trucks and cars have such different acceleration, braking, and other characteristics that it is widely accepted they would have to be separately handled on future electronic guideways.

Marcuson suggests that in designing rebuilds of America's urban expressways, careful study should be done of the potential for making more efficient use of the available right-of-way through separation of high profile and low-profile vehicles. This would improve conditions now and also help prepare for highway automation. "A separate but parallel facility (for high profile vehicles) would allow for the different operating characteristics of small and large vehicles, allowing different speed limits and different design criteria, both structural and geometric," he writes.

Marcuson has drawn up a set of notional highway cross-sections showing how high and low vehicles (trucks and buses vs. cars, pickups and small vans) might usefully be separated to provide more lanes and better safety in typical wide rights-of way. Some of his designs show a very standard Los Angeles right-of-way and how by double-decking the light-vehicle roadway in the middle, fourteen lanes could be achieved in place of the existing eight lanes.

Another design shows an alternative with the double-decked cars-only lanes on the outside, gaining a fifty percent increase in laneage within the same right-of-way. A further visualization takes a wider cross-section of the kind quite common in Los Angeles of an existing ten-lane right-of-way and puts a double-deck cars-only roadway alongside a four-lane facility for the high vehicles, yielding sixteen lanes. Further drawings show a Texan-style expressway of ten-lanes with frontage roads on each side and, by building structures in place of the frontage roads, getting twenty-four lanes in place of the existing fourteen lanes. Marcuson's sketches are shown in Figures 13 through 19.

Figure 13: Marcuson Exhibit 1

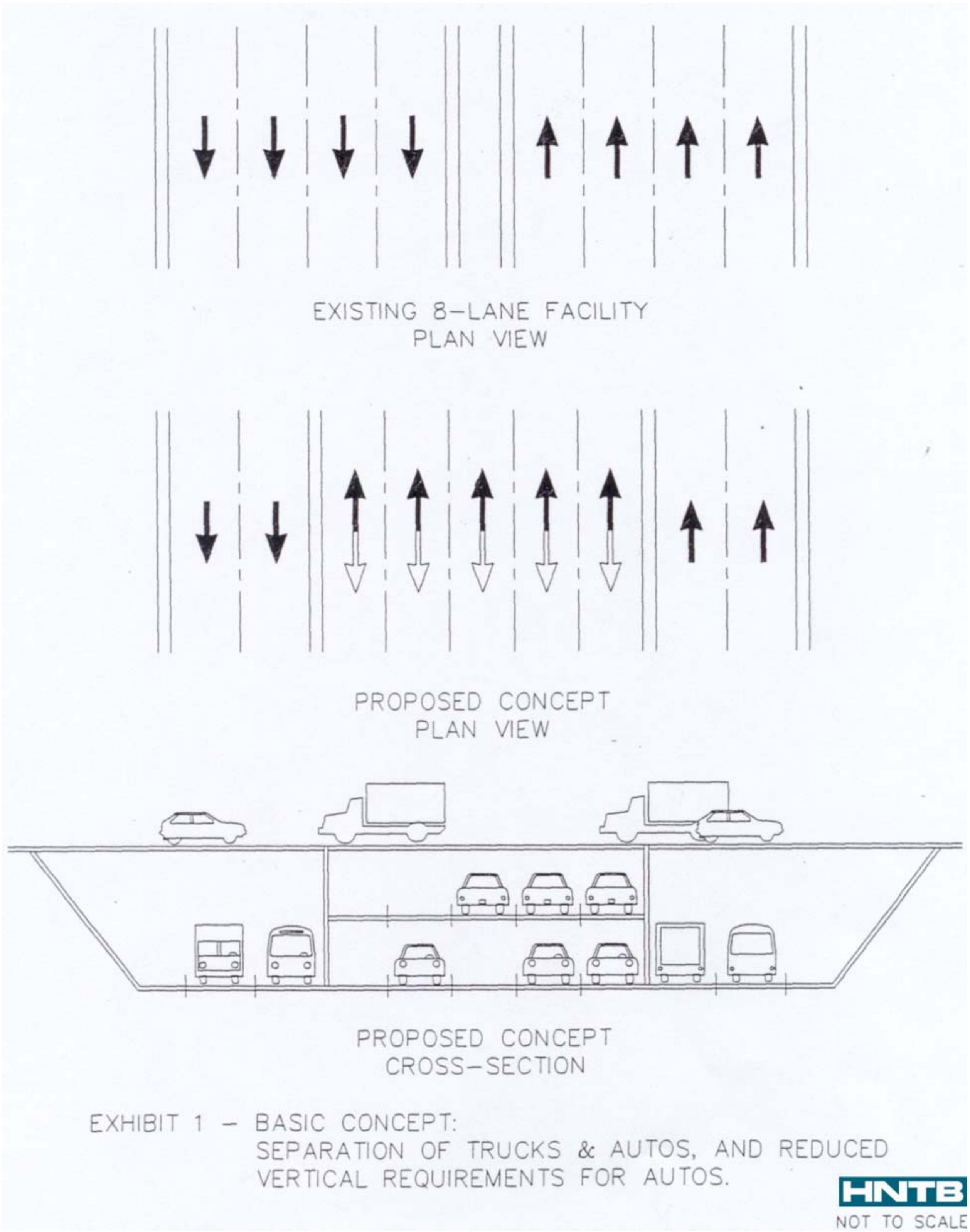


Figure 14: Marcuson Exhibit 2

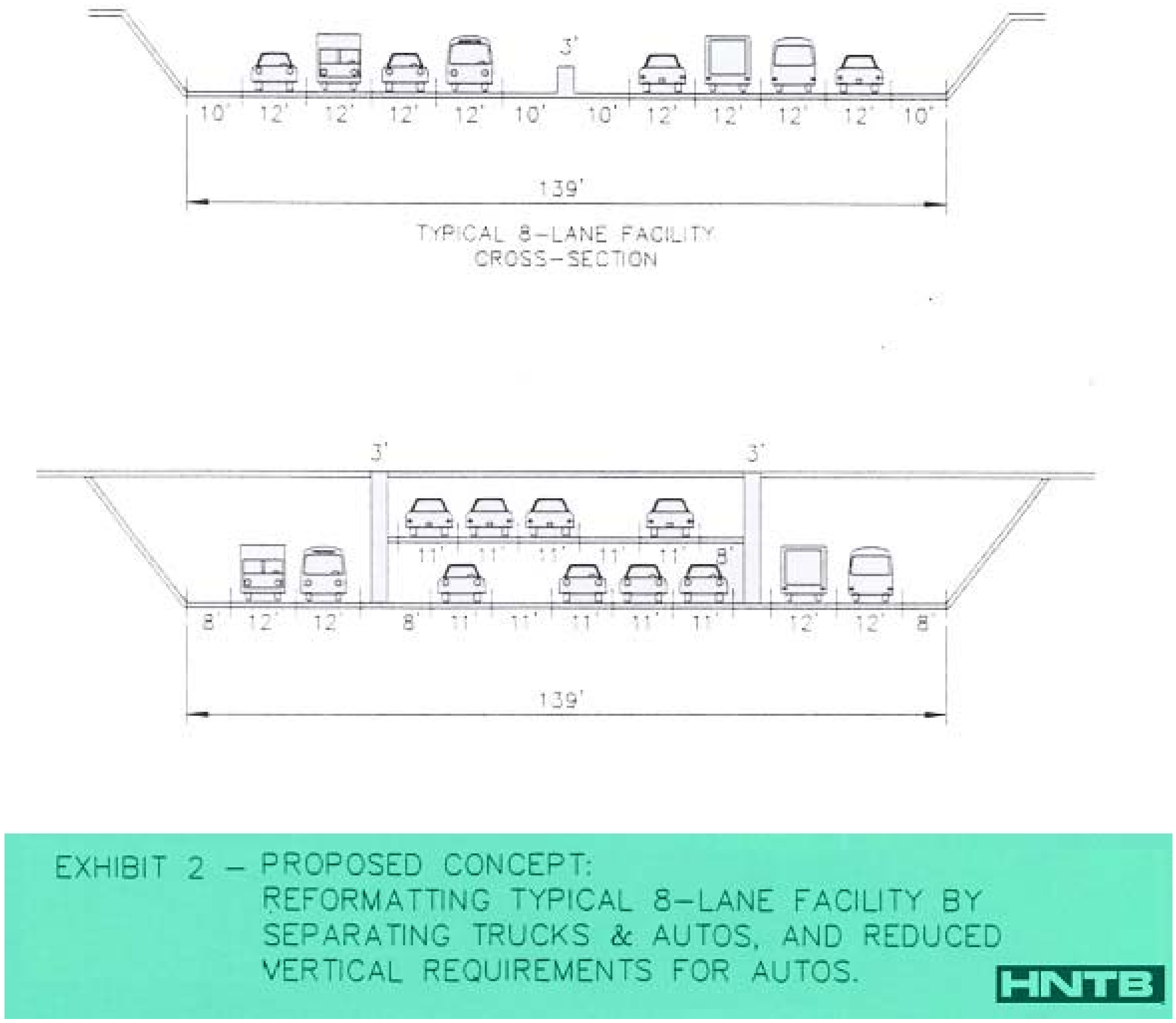


Figure 15: Marcuson Exhibit 3

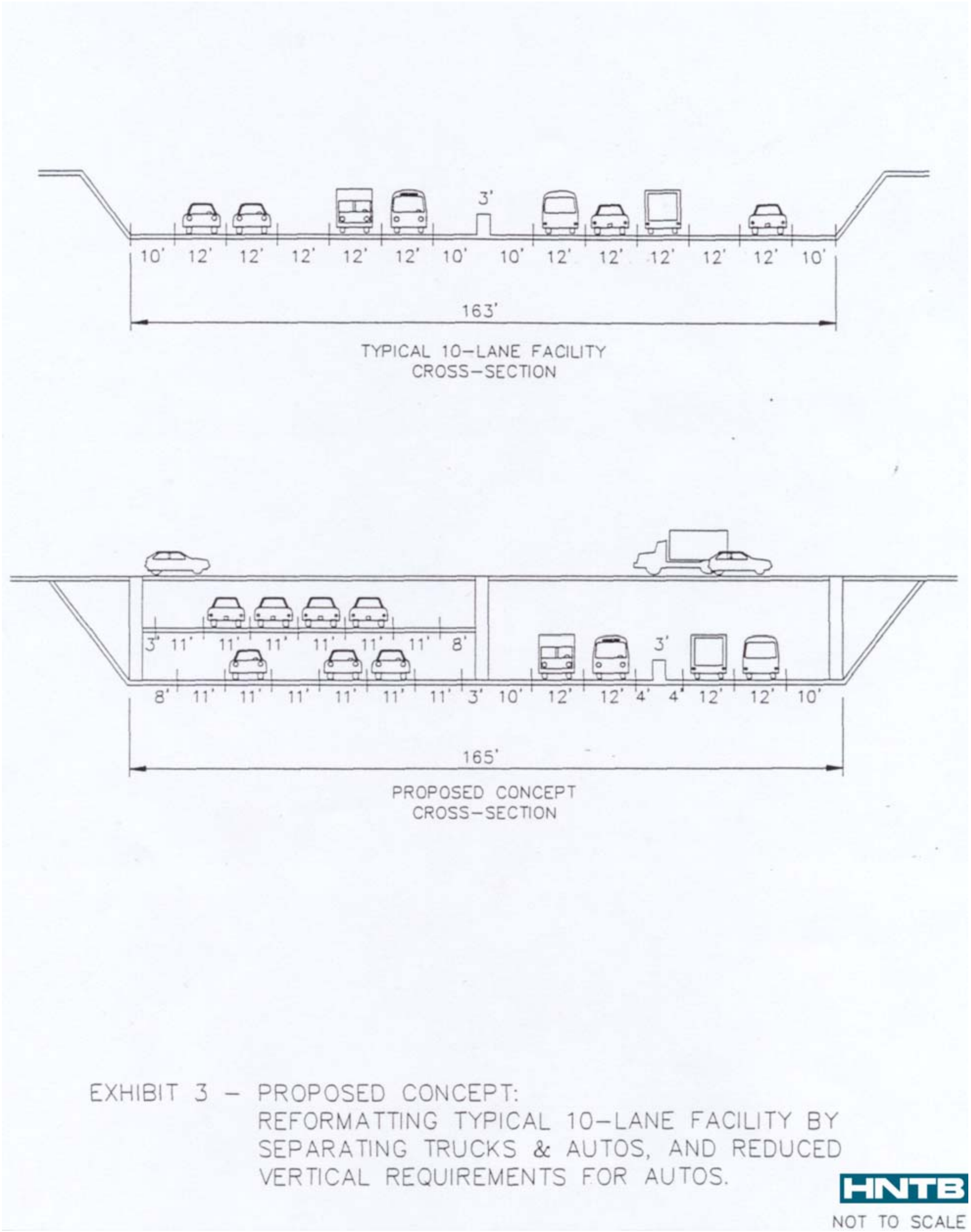


Figure 16: Marcuson Exhibit 4

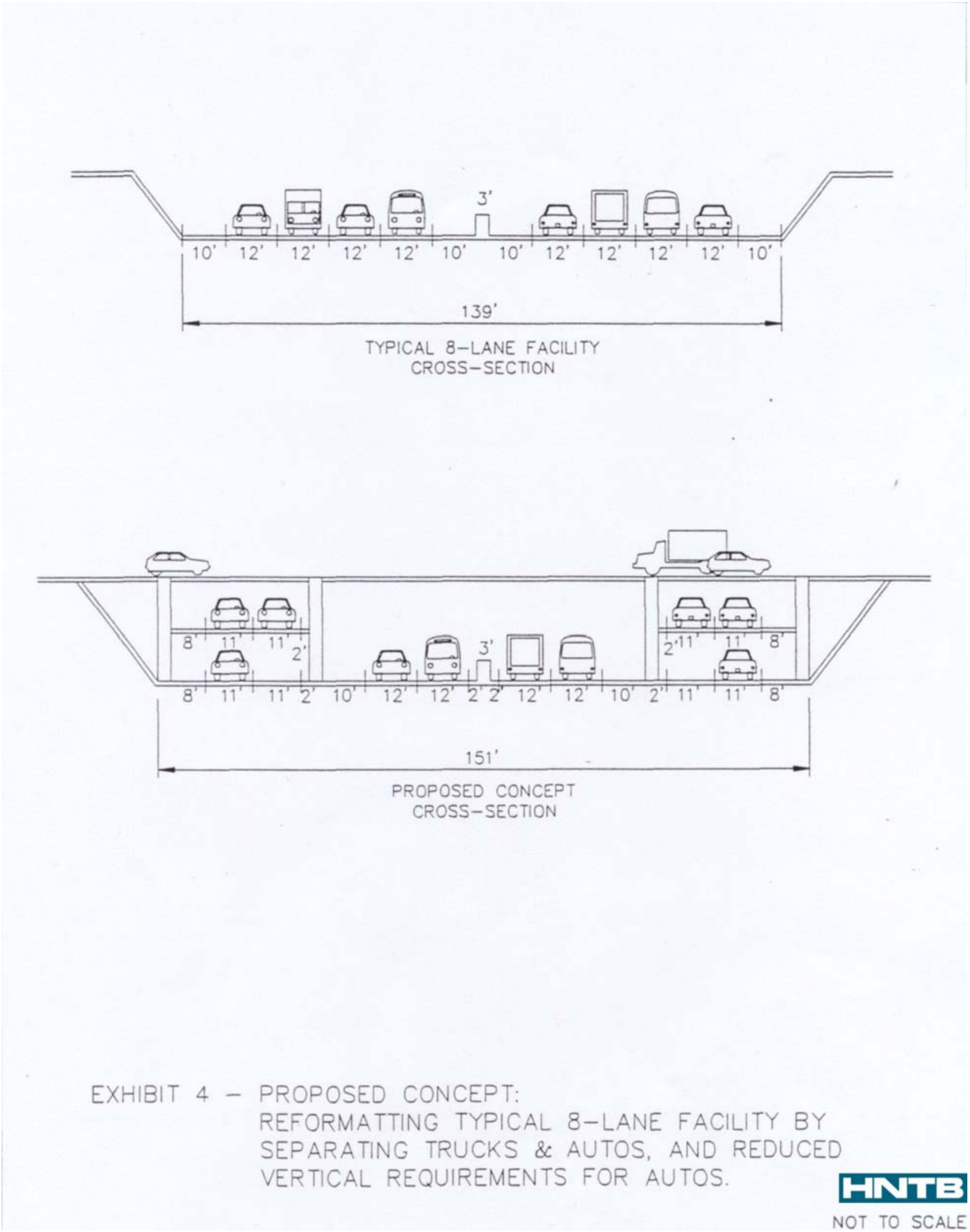


Figure 17: Marcuson Exhibit 5

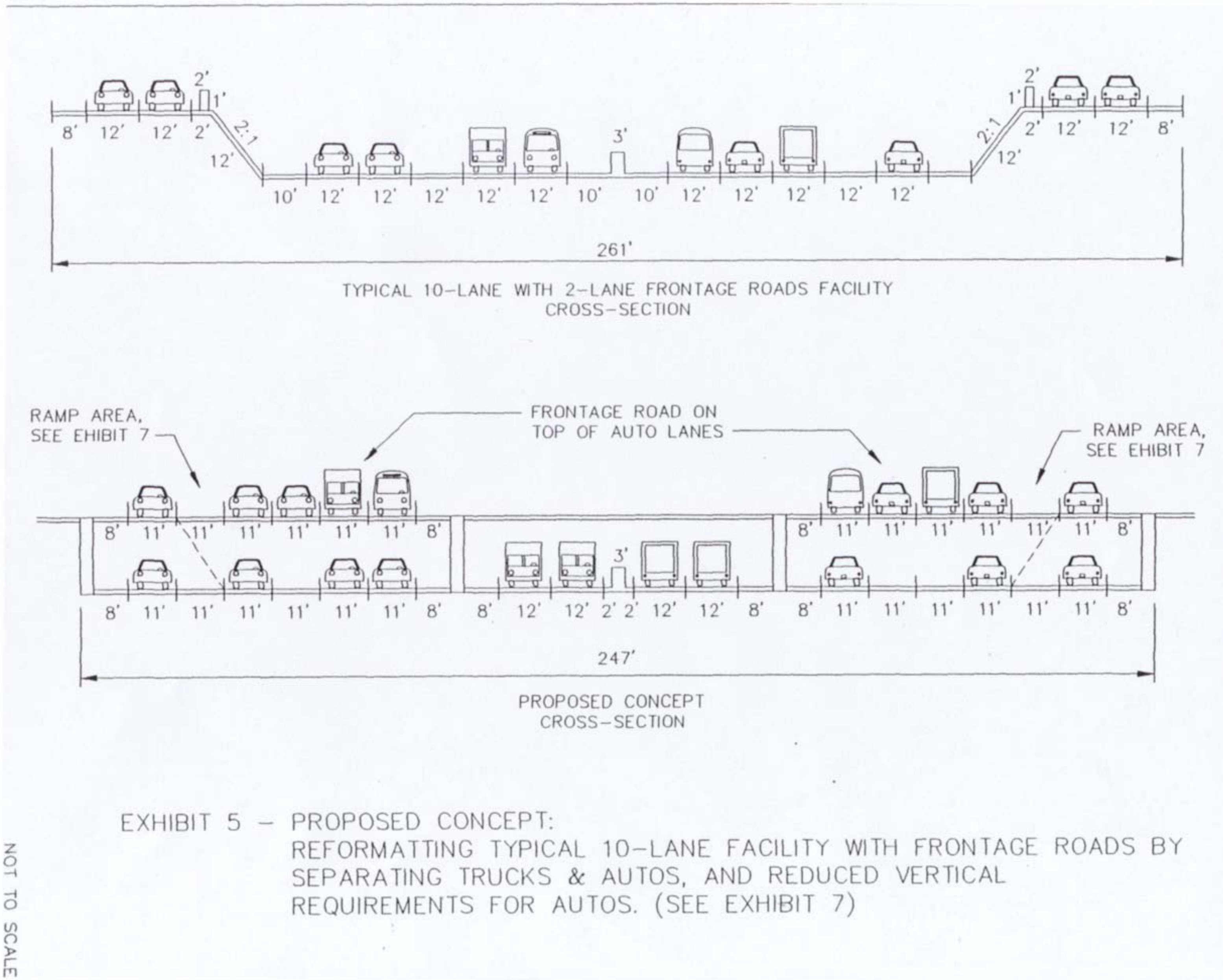


Figure 18: Marcuson Exhibit 6

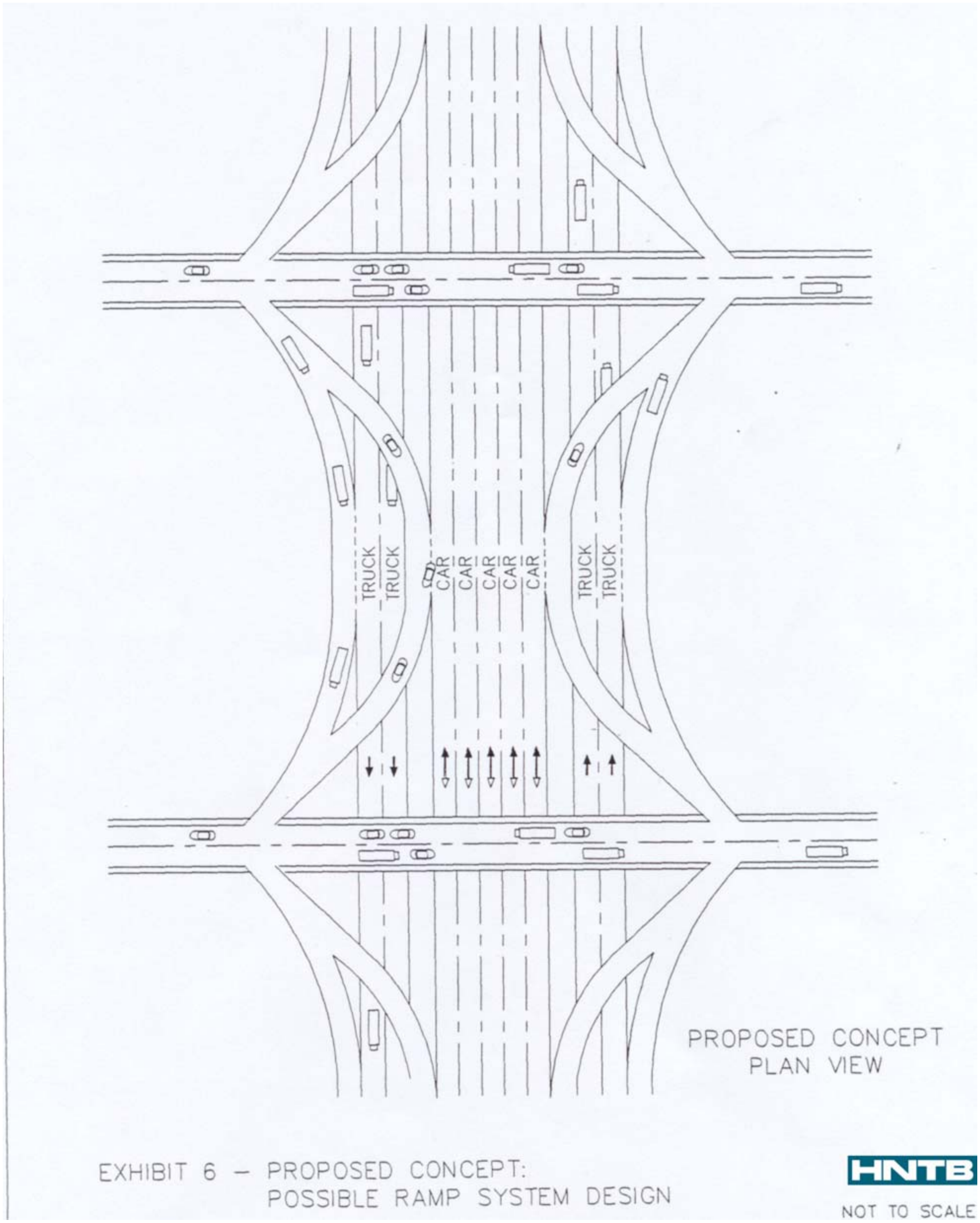
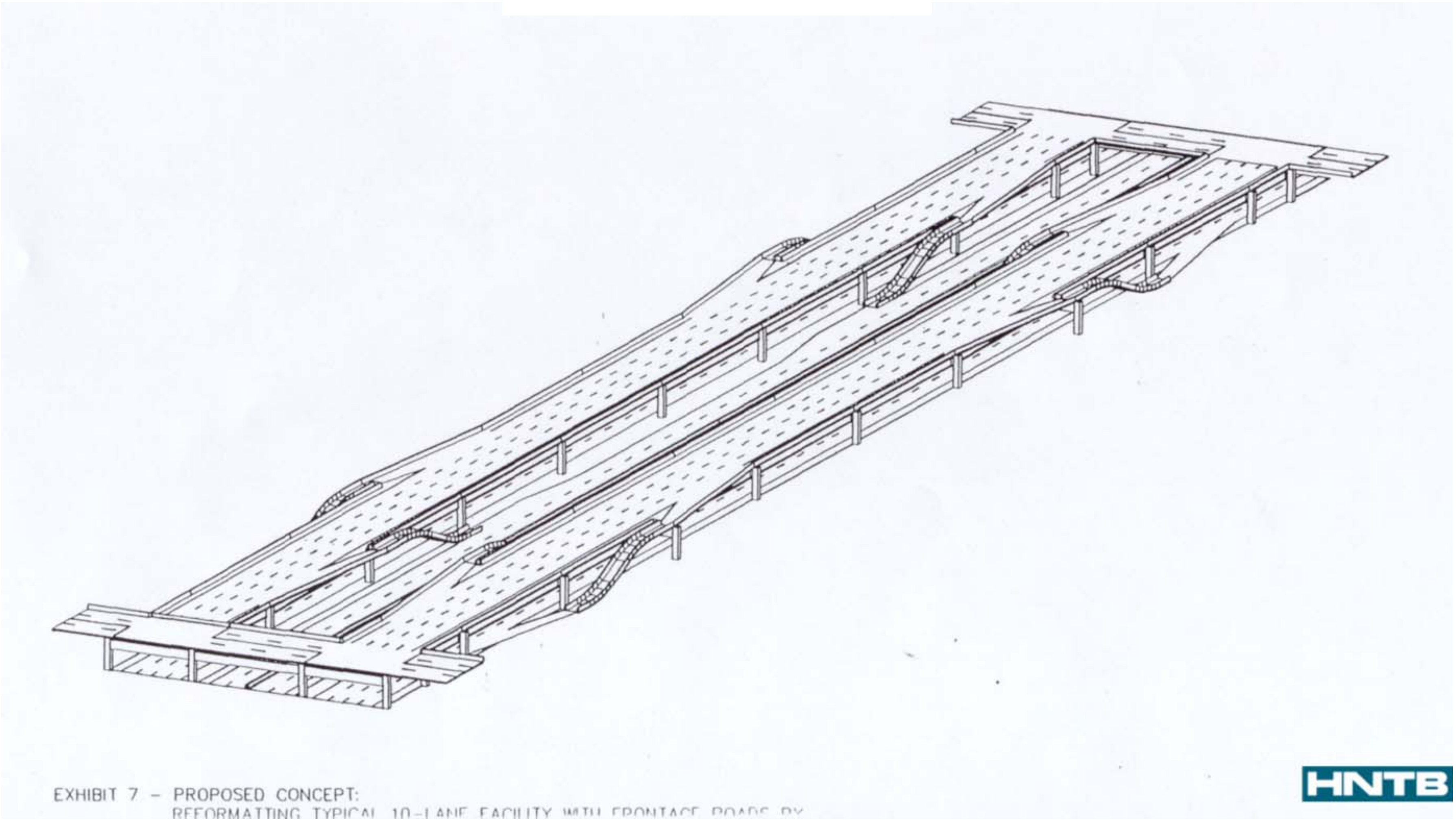


Figure 19: Marcuson Exhibit 5



A business group called STAR Solutions led by James Atwell, former commissioner of finance for Virginia Department of Transportation, now an independent consultant, has proposed constructing four truck lanes in I-81 in Virginia, which is 325 miles in return for the right to toll the trucks. There would also be four light vehicle lanes. I-81 is a major trucking route between New York, the Carolinas, Texas and Mexico. It remains to be seen whether this $4 billion project can be consummated but it promises to finance widening of the highway in ten years with only tax money might take thirty years.

In 1996 Wilbur Smith Associates and HNTB did a feasibility study of various types of roadway along the route Toronto-Detroit-Indianapolis-Evansville-Memphis-Houston-Laredo, the so-called NAFTA (North American Free trade Area) highway, designated a Congressional High Priority corridor. The consultants found that by building the highway for heavy trucks to 132,000 pounds - the Canadian standard compared to the U.S. federal 80,000 pound limit at a cost of $6.2 billion it would yield a return of 16.5% on investment compared to the 9.9% estimated return on $5.5 billion building it only to the standard US federal truck size of 80,000 pounds. The consultants envisaged outer truck lanes of 13' width for trucks up to triple trailer configuration, as well as gentler interchange radii and longer climbing and merge and diverge lanes than normal. Similar advantages might inure to urban truck tollways.

On truck-only roads with vehicles of similar performance, passing may not be needed and it may be possible to operate them safely with only one travel lane each direction and maybe a single central buffer median for breakdowns making the total pavement only 34' wide — a facility that would fit many abandoned railroad rights-of-way. Long distance trucks will be among the first vehicles to use various high-tech collision avoidance, intelligent cruise control and automatic lane keeping devices.

Eligibility

The primary reason for separating light vehicles from heavy trucks in high volume corridors is safety. Cars in the weight range 3,000 to 5,000 pounds do not operate safely with vehicles 50,000 to 100,000 pounds. The 20-fold difference in weight between an automobile and a tractor-trailer or other combination vehicle makes them incompatible. They have different acceleration and braking, different sight lines, different cornering and stability characteristics. They therefore have different roadway requirements.

Another reason for specialized roadways is traffic management. Narrow corridors such as old railroad rights-of-way are often 50 feet wide; a width that could accommodate a pair of 13' truck lanes and shoulders with some room for walling and planting. Or the width could accommodate a cars-only roadway of four 10' lanes, plus median and walling, but no full shoulders. Such a road would be overloaded if you open it to all vehicle types. Truckways could in practice allow buses so a possible classification could be trucks and busways.

To screen traffic from neighboring houses the pavement of any road carrying tractor-trailers, whether it is a mixed traffic highway or a specialized truckway, will require either having the level depressed at least 20’ or heavy walling of this same height. However a cars-only road with vehicles limited to about 6’ height will require much less drastic screening to contain noise and visual impacts.

Metroroutes

The French have gone furthest in systematically studying car/truck segregation in the context of underground construction. Traffic congestion in the Paris region in the context of political problems and costs associated with acquiring surface land for new motorways produced intensive study in the past 20 years of schemes for underground roads. In 1987 Francois Lemperiere of the GTM engineering company was credited with the idea of using a 33’ diameter tunnel that would normally house just two lanes of roadway for unrestricted-size vehicles to provide a three-fold increase in capacity. He showed a design for using the same tube to provide two levels with three-lanes each for vehicles of 6’-7” maximum height in lanes of about 10’. He pointed out that this would transform the prospect of financing urban toll motorways in tunnels. Out of Lemperiere’s conceptual proposal came a government-organized commission to study safety issues and work to produce specifications for light vehicle underground road networks. In June 1992 the Center for the Study of Tunnels (CETU), central government officials and city officials from Paris and Nice produced specifications translated as Recommendations on Reduced Height Urban Tunnels (known by the acronym RECTUR) suggesting three standards for what have come to be called ‘metroroutes.’ The name was a take from ‘Metro’ for metropolitan subway, and the French saw this as a possible system or network of underground roads that could be applied under major cities to supplement and link together existing surface motorways.

The vehicle height standards set by RECTUR were:

- 6’-7” which covers 85% of vehicle types in the Paris region excluding minibuses in which passengers can stand, and all existing emergency vehicles
- 8’-10” allows most ambulances and the minibuses
- 11’-6” allows urban buses and most fire equipment, but not heavy trucks or long-distance coaches

RECTUR recommended 1’-8” above the height of the highest allowable vehicle for hanging signs and for psychological comfort so in the case of 2m-max vehicle tunnels the ceiling would be at 8’-4”. The committee researched the lane width needs and offsets from walls. Cofiroute decided on the 6’-7” standard for the six-mile length toll tunnel for the A-86 West project in Versailles. Cofiroute found the benefits of the larger limits did not come near the extra costs. Special low height emergency vehicles will be built. It estimates that in rush hours, when such a toll facility will be in greatest demand, well over 90% of traffic will fit into the 6’-7” gauge of the tunnel portals. It estimates the tunnel will carry up to 8,000 vehicles/hour and average daily traffic of 100,000. Posted

Speed limit will be 43 mph with automated speed ticketing at 50 mph. The tight dimensions will encourage this kind of low average speed driving, but it also maximizes vehicle throughput and is considered likely to produce very safe travel. Another cost saver in excluding heavy vehicles is the ability to design in steep grades and tighter curves, especially helpful in reducing costs of ramps at interchanges. A maximum grade of 12% was specified by the RECTUR report.

The A-86 West small gauge tunnel will use air ducts, separate for each level. In case of fire or accidents stairways will allow motorists to use the alternate level as refuge from smoke, and emergency services will be able to block off the other level and operate from there. Cofiroute officials have said they will probably begin operations of the tunnel with only two-travel lanes on each level with the third as breakdown buffer area and merge/diverge lane at interchanges, but may run all three-lanes if traffic is heavy. Estimated cost is $180m/mile.

The Paris regional plan for 2015 lays out 65 miles of metroroutes, and they have also been considered for a new motorway to the Roissy Charles de Gaulle Airport and as additional capacity for the southern part of the Boulevard Peripherique or inner ring road. Metroroutes seem to have considerable potential in a number of large dense European cities, especially in London. In the US they would seem to be most applicable in:

- New York City, especially in Brooklyn and Queens where the elevated Gowanus and Brooklyn-Queens Expressways (I-278) are rapidly deteriorating
- In the Passadena 'missing link' between I-710 and I-210
- To complete the missing link in US-101 between Mission St and the Presidio in San Francisco
- Revitalization of Washington DC inside the Beltway by completing as small gauge tunnels some of the abandoned radials (I-270, I-95) and US-1 in Alexandria.

Americans have more big tire sports utility and high van type vehicles than the Europeans and application of the French standards would probably exclude too many US vehicles, so somewhat more generous dimensions for carways would likely be needed here. But the principle remains the same — that dimensioning certain road structures for exclusive use by smaller vehicles which constitute about 90% of rush hour traffic flows can produce huge savings, as the French have demonstrated, and allow road projects that would otherwise be uneconomic to be financed. They will also allow more efficient use of scarce real estate for pavement and allow more efficient screening of traffic from neighbors.